performed by moving the focal point of the light beam toward the information surface of the disc as shown by the dashed arrow in FIG. 19C. When the LPF output reaches the stored lower limit L(IN1), the output is kept unchanged and the focal point of the light beam waits at the corresponding location IN1. Then the disc **101** moves toward the focal point of the light beam, and at the location IN2, an S-shape signals shown in FIG. **4** appears in the focus error signal FE. A predetermined pull-in level corresponding to the S-shape signal is then detected, thereby the focus loop is closed. Similarly, if the focus is out of control when the light beam is located at the outer periphery of the disc, the retry of the pull-in is performed by moving the focal point of the light beam toward the information surface of the disc as shown by the dashed arrow in FIG. 19C. When the LPF output reaches the stored lower limit L(OU1), the output is kept unchanged and the focal point of the light beam waits at the corresponding location OU1. Then the disc **101** moves toward the focal point of the light beam, and at the location OU2, an S-shape signal such as that shown in FIG. **4** appears in the focus error signal FE. A predetermined pull-in level corresponding to the S-shape signal is then detected, thereby the focus loop is closed.

Unlike in Example 2, according to Example 4 of the present invention, it is not necessary to gradually move the converging lens **107** toward the disc for detecting the lower axial deviation limit, whereby the faster focus pull-in is achieved. Therefore, the optical disc apparatus of Example 4 is very effective in the case where the retry of pull-in is performed within a limited process time.

In the structure described above, the lower limit stored in the lower limit storing section **142** is continuously updated during a reproduction or a waiting. Alternatively, the optical disc apparatus according to the present example may be configured to detect and store, at the start of the operation, more than one lower limit corresponding to more than one location located in a radius direction of the information medium. For example, the lower limits at the inner and outer peripheries, or more than one lower limit at any other of a plurality of locations, can be stored. Based on the more than one lower limit stored in the lower limit storing section **142**, the suitable lower limits corresponding to desired locations in a radius direction of the information medium, can be obtained by calculations such as linear complement or functional approximation. A calculation section for performing such a calculation may be provided in the lower limit storing section **142**. Similar effects can be achieved by using the lower limit corresponding to any locations on the information medium for determining the wait level of pull-in (i.e., the waiting location) at the location where the focus went out of control.

Furthermore, by incorporating the structure relating to the detection and storing of the lower axial deviation limit into the configuration described in Example 1 or 3, more reliable optical disc apparatus is provided.

As described above, the focus pull-in section according to the optical disc apparatus of the present invention first determines whether or not the focal point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation. If it is determined that the focal point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation, the focus pull-in section turns ON the control of the focus servo control section. Therefore, even if the rotation speed of the disc is high and the axial deviation speed is significant, it is possible to achieve a stable focus pull-in and following in a reduced time.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

What is claimed is:

1. An optical disc apparatus comprising:

a converging section for converging a light beam and irradiating a rotating information medium with the converged light beam;

a moving section for moving the converging section, thereby moving a converging point of the converged light beam in a direction perpendicular to an information surface of the information medium;

a converging state detection section for generating a focus servo signal which represents a converging state of the light beam on the information medium based on reflected light or transmitted light of the light beam from the information medium;

a focus servo control section for controlling the moving section based on the focus servo signal, so that the light beam reaches a predetermined converging state on the information medium; and

a focus pull-in section for turning ON the control by the focus servo control section,

wherein the focus pull-in section turns ON the control by the focus servo control section in a case where the focus pull-in section determines that the converging point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation.

2. An optical disc apparatus according to claim **1**, further comprising an S-shape signal detection section for detecting S-shape signals which appear in the focus servo signal when the converging point of the light beam contacts the information surface of the information medium,

wherein the focus pull-in section determines whether or not the converging point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation.

3. An optical disc apparatus according to claim **2**, further comprising a detected interval measuring section for measuring an interval between temporally adjoining two of the S-shape signals,

wherein the focus pull-in section determines that the converging point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation when the interval exceeds a predetermined first period of time.

4. An optical disc apparatus according to claim **3**, wherein the S-shape signal detection section detects the S-shape signals by either moving the converging point of the light beam toward or away from the information surface of the information medium, or making the converging point of the light beam wait at a predetermined position.

5. An optical disc apparatus according to claim **4**, wherein the S-shape signal detection section detects the S-shape signals by retrying to move the converging point of the light beam toward the information surface of the information medium at a predetermined speed, in the case where the interval is not output from the detected interval measuring section after the elapse of time required for one revolution of the information medium.

6. An optical disc apparatus according to claim **5**, wherein a retry speed of the converging point of the light beam is set

so as to be smaller than a speed of the previous motion toward or away from the information surface of the information medium.

7. An optical disc apparatus according to claim 4, wherein the S-shape signals are detected by making the converging point of the light beam wait at a predetermined position in the case where the interval is not output from the detected interval measuring section after the elapse of the first period.

8. An optical disc apparatus according to claim 2, further comprising a time width measuring section for measuring a time width of a predetermined portion of an S-signal,

wherein the focus pull-in section determines that the converging point of the light beam is located in the vicinity of the minimum velocity position on the information medium axial deviation when the interval exceeds a predetermined second period of time.

9. An optical disc apparatus according to claim 8, wherein the S-shape signal detection section detects the S-shape signal by either moving the converging point of the light beam toward or away from the information surfaces of the information medium, or making the converging point of the light beam wait at an predetermined position.

10. An optical disc apparatus according to claim 9, wherein the S-shape signal detection section detects the S-shape signals by retrying to move the converging point of the light beam toward the information surface of the information medium at a predetermined speed, in the case where the interval is not output from the detected interval measuring section after the elapse of time required for one revolution of the information medium.

11. An optical disc apparatus according to claim 10, wherein a retry speed of the converging point of the light beam is set so as to be smaller than a speed of the previous motion toward or away from the information surface of the information medium.

12. An optical disc apparatus according to claim 9, wherein the S-shape signal detection section detects the S-shape signals by making the converging point of the light beam wait at a predetermined position in the case where the interval is not output from the detected interval measuring section after the elapse of the time required for one revolution of the information medium after the time when one of the S-signals was detected, or the elapse of the first period which is slightly shorter than the time required for one revolution of the information medium.

13. An optical disc apparatus according to claim 1, wherein the focus pull-in section turns ON the control by the focus servo control section when it is detected that the level of the focus servo control section reaches a predetermined pull-in level.

14. An optical disc apparatus according to claim 4, wherein the focus pull-in section further comprises a moving speed switching section for switching the moving speed of the converging point of the light beam in response to the polarity of the S-signals when the focus pull-in section moves the converging point of the light beam toward or away from the information surface of the information medium.

15. An optical disc apparatus according to claim 10, wherein the focus pull-in section further comprises a moving speed switching section for switching the moving speed of the converging point of the light beam in response to the polarity of the S-signals when the focus pull-in section moves the converging point of the light beam toward or away from the information surface of the information medium.

16. An optical disc apparatus according to claim 4, further comprising a rotation speed measurement section for measuring the rotation speed of the information medium,

wherein the focus pull-in section sets the first period of time or the predetermined speed based on the rotation speed measured by the rotation speed measurement section.

17. An optical disc apparatus according to claim 9, further comprising a rotation speed measurement section for measuring the rotation speed of the information medium,

wherein the focus pull-in section sets the second period of time or the predetermined speed based on the rotation speed measured by the rotation speed measurement section.

18. An optical disc apparatus according to claim 2, further comprising a information medium identification section for identifying the type of the information medium by a signal based on reflecting light or transmitting light from the information medium,

wherein the focus pull-in section determines a moving speed or a waiting position of the converging point of the light beam when the focus pull-in section moves the converging point of the light beam toward or away from the information surface of the information medium, or makes the converging point of the light beam wait at a predetermined position.

19. An optical disc apparatus according to claim 18, wherein the conversion point of the light beam, moving toward the information surface of the information medium, is kept at a predetermined driving value based on the detection result of the type of. the information medium, whereby the conversion point of the light beam is kept from approaching unnecessarily close to the information medium.

20. An optical disc apparatus according to claim 1, further comprising a lower limit detection section for detecting the lower limit of an output signal of the focus servo control section or an input signal thereof during the operation of the focus servo control section, and a lower limit storing section for storing the detected lower limit,

wherein, in the case where the focus servo control section is restarted after the focus servo control section if OFF: it is determined that the converging point of the light beam is in the vicinity of the minimum velocity position on the information medium axial deviation when the conversing point of the light beam contacts on the information surface of the information medium until the output signal or the drive signal reaches the lower limit by driving the moving section; and the focus pull-in section performs a retry operation which restarts the control by the focus servo control section when it is determined that the level of the focus servo signal reaches a predetermined pull-in level.

21. An optical disc apparatus according to claim 20, wherein the lower limit storing section stores more than one lower limit which corresponds to more than one location located in the radius direction of the information medium, and the optical disc apparatus further comprises a calculation section for calculating the lower limit corresponding a predetermined location in a radius direction of the information medium based on the at least one lower limit.

22. An optical disc apparatus according to claim 20, wherein the lower limit detection section operates during the operation of the focus servo control section, whereby the stored value of the lower limit storing section is continuously updated.

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